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FORMATION OF THE CRYSTAL STRUCTURE OF THE SURFACE OF RUBY UNDER THE EFFECT OF SURFACE-ACTIVE MEDIA IN DIAMOND POLISHING

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The selective effect of surfactants on weakening of interatomic bonds along certain crystallographic planes in the surface layer of a single crystal of ruby undergoing polishing was revealed.

Mechanical polishing of solids, whose basic application is to obtain surfaces of the required quality, is a combination of plastic deformation and very fine dispersion of the treated surface. In abrasive treatment of single crystals, we can arbitrarily distinguish two stages of dispersion:

breaking up the initial single crystal structure into individual grains and crystallites with formation of defects, future sites of fracture, without perturbing the continuity of the monolith;

abrasion, separation of small particles from the treated surface.

In the real treatment process, both stages of dispersion are conducted simultaneously and are interdependent.

The microrelief and atomic-molecular structure of the treated surface are formed in its reaction with the abrasive grains. The surfactants in the polishing compositions change the deformation-strength properties of the thinnest (tenths and hundredths of a micron) surface layer of the treated material due to the Rebinder effect and significantly affect formation of its surface in abrasive treatment.

We investigated the effect of the individual components of polishing compositions with different physicochemical properties on formation of the crystal structure in the surface layer of a brittle solid (ruby) during fine diamond-abrasive treatment.

The ruby single crystal was treated along plane (111) on a flat-lapping machine with a corundum lap of a suspension of diamond powder with 3/0 μm granularity. Vaseline oil, oleic acid, and water were used as the lubricant-dispersion media. For comparison, treatment with dry diamond powder was conducted. During polishing, the outer surface layer of the samples which appeared in the preceding treatment stages was totally removed.

The crystal structure of the surface of the samples was investigated in an electron microscope by the reflection electron diffraction method (with 65 keV energy), which allows obtaining electrongrams from a section 50 μm wide. The slope angle of the electron beam with respect to the surface of the sample was 0.5 – 1°, which ensured penetration of electrons to a maximum depth of 100 Å. A special instrument — an ion gun that bombarded the sample with residual gas ions — made it possible to totally remove charges arising on the ruby sample.

The electrongrams were identified together with the data from a study by E. N. Maslen, et al. [1]. The results of the studies showed that the crystal structure of the surface of the samples is a function of the physicochemical properties of the lubricant-dispersion medium to a significant degree. Shearing (peeling) of microparticles takes place not only along plane (111), which is treated, but also along other crystallographic planes. This results in the formation of small irregularities (facets).

Treatment with dry powder with no lubricant is accompanied by fracture of the initial single-crystal structure and the appearance of a polycrystalline, coarsely disperse structure with a 3000 – 6000 Å grain size. A pronounced face texture is observed, formed by predominant shear of the particles along faces (113). There is no azimuthal texture.

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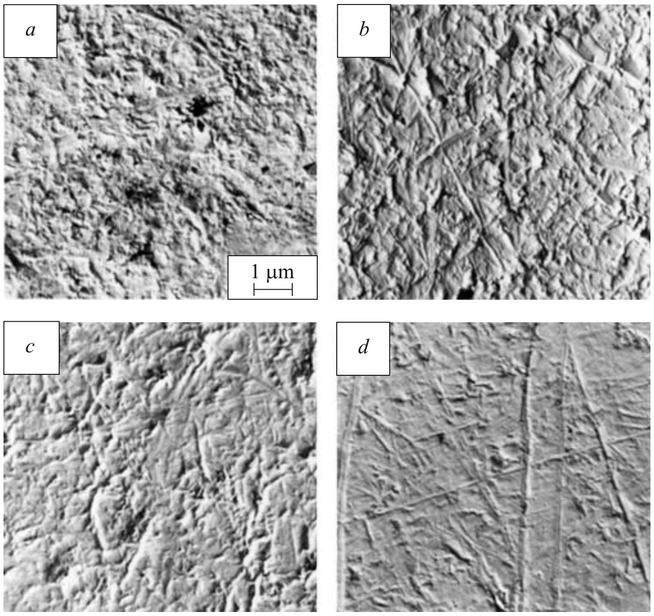

Fig. 1. Electron microscopic photographs of the surfaces of samples treated dry with no lubricant (*a*), using oleic acid (*b*), vaseline oil (*c*), and water (*d*).

The use of Vaseline oil as the lubricant-dispersion medium sharply changes the surface crystal structure. The size of most grains decreases to 300 Å. The face texture decreases slightly due to the appearance facets along plane (110) in addition to the facets along faces (113).

The surface of the ruby after treatment with oleic acid is a disperse system and the majority of the grains are approximately 200 Å in size. The shear plane of the facets changes in this case, and the face texture is formed as a result of shear along faces (110).

Water causes formation of the most finely disperse structure in the surface layer of corundum with strongly deformed grains 100 – 150 Å in size. The absence of any texture in this case is due to the equally probable fracture and deformation

TABLE 1

Polishing composition	Crystallite-grain size, Å	Shear planes of facets
Dry powder ASM 3/0	3000 – 6000	113
ASM 3/0 + vaseline oil	300	113 + 110
ASM 3/0 + oleic acid	200	110
ASM 3/0 + water	100	Equally probable shear over all crystallographic planes

of the initial structure over all crystallographic planes due to the important decrease in the strength under the effect of the surface-active medium.

These findings indicate the selective effect of surface-active media on weakening of interatomic bonds along defined crystallographic planes, which is probably due to the anisotropy of their electrical and other properties.

The generalized data on the effect of different SF on formation of the crystal structure of surface (111) of a single crystal of corundum in diamond polishing are reported in Table 1 and photographs of the surfaces of samples treated with different lubricant media are shown in Fig. 1.

The selective effect of surface-active media on weakening of interatomic bonds over defined crystallographic planes in the surface layer of ruby during fine abrasive treatment was thus discovered.

The data obtained should be taken into consideration in making up polishing solutions to obtain the optimum combination of microtopographic, structural-mechanical, optical, and other properties of the treated surface.

REFERENCES

1. E. N. Maslen, V. A. Streltsov, and N. R. Streltsova, “Synchrotron x-ray study of electron density in AlO,” *Acta Cryst.*, **49**, 973 – 980 (1993).